山东大学 SHANDONG UNIVERSITY
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# Agreement on Joint Research on

RHIC/STAR-TPC detector upgrade and the experimental study on Beam Energy Scan II

between

Shandong University & the STAR Collaboration

## I. Collaborative Research Title

RHIC/STAR-TPC detector upgrade and the experimental study on Beam Energy Scan II

## II. Leading Scientists

Party A:

Principal Investigator: Prof. Dr. Qinghua Xu

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Address: 27 Shanda South Road, Jin'an, Shandong 250100

Main Participants (Participating Universities/Institutes and other Institutions):

Prof. Liang Xue, Shandong University (SDU)

Dr. Jian Deng, SDU

Mr. Yansheng Sun, SDU

Mr. Peng Lu, SDU

Mr. Hui Zeng, University of Science and Technology of China (USTC)

Dr. Chi Yang, USTC

Mr. Qian Yang, USTC

Prof. Dr. Jinhui Chen, Shanghai Institute of Applied Physics, CAS (SINAP)

Dr. Longxiang Long, SINAP

Party B:

Principal Investigator: Dr. Flemming Videbaek

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Tel.: +1 631 344-4106

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Address: Brookhaven National Laboratory (BNL), Upton, NY 11973

Main Participants (Participating Universities/Institutes and other Institutions):

Dr. Zhangbu Xu (BNL)

Dr. James Thomas (Lawrence Berkeley National Laboratory)

Dr. Tonko Ljubicic (BNL)

Prof. Jerry Hoffmann (University of Texas at Austin)

## III. Research Plan, Division of Labor and Timetable

The project aims to study the property of QGP and to search for the QCD phase transition in the phase digram. We propose to achieve this goal by upgrading the inner sectors of Time Projection Chamber (iTPC) at STAR and completing the Beam Energy Scan phase II (BES-II) at RHIC. The BES II will run heavy ion collisions at different energies. The improved acceptance with the proposed iTPC upgrade at STAR, resulting in an increase in the measured particles of 70-80%, will provide several significant improvements to our sensitivity to the proposed quantities (including elliptic flow, multiplicity moments and di-leptons) to search for the critical point.

The project will strengthen the collaboration between Chinese institutes (SDU, USTC and SINAP) and the STAR experiment at the Brookhaven National Laboratory, and both parties will benefit significantly from this project if it succeeds. The plan for both sides is to work on the study of QCD phase transition in relativistic nuclear collisions, which includes both participating in the iTPC detector upgrade and the data analysis for the STAR experiment.

The project consists of detector upgrades and physics analysis, which can be

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implemented by the following participating institutes:

Unit A: SDU, USTC and SINAP

Title: Construction of iTPC MWPC chambers and the BES-II data analysis

Investigators: Prof. Qinghua Xu, Dr. Jian Deng, Mr. Yansheng Sun, Mr. Peng Lu, Prof. Liang Xue, Mr. Qian Yang, Mr. Hui Zeng, Dr. Chi Yang, Prof. Jinhui Chen, Dr. Longxiang Liu

The goal of this group is to construct the iTPC MWPC chambers for the iTPC upgrade at STAR and to search for the phase boundary in QCD phase transition with BES-II data. We propose to upgrade the inner sectors of the STAR TPC to increase the segmentation on the inner pad plane and to renew the inner sector wires. The upgrade will provide better momentum resolution, better dE/dx resolution, and most importantly it will provide improved acceptance at high rapidity to |eta|<1.7 compared to the current TPC configuration of |eta|<~1.0. Currently only 20% of the path length of the charged particle traversing the TPC inner sector has been sampled by the electronics readout and the iTPC upgrade will increase the coverage to 100%. The design and construction of iTPC chambers includes the following three main aspects: 1) design the procedure and technique of detector construction; 2) mass production of 24 MWPC sectors and the test of them.

With the data that will be collected with BES-II, this group will search for the signal of phase transition through the following channels at the different energies: 1) Spectra and elliptic flow of Phi and Omega; 2) Beam Energy dependence of Helium 3 production in AuAu collisions.

Unit B: Brookhaven National Lab and others

Title: DAQ system of iTPC, strongback and the search of QCD critical point

Investigators: Dr. F. Videbaek, Dr. Zhangbu Xu, Dr. J. Thomas, Dr. T. Ljubicic, Prof. J. Hoffmann

This group is responsible for the electronics system of the iTPC upgrade at STAR, strongback production, and also joins the data analysis. STAR has upgraded its TPC readout in 2008 with new electronics (ALTRO+PASA). The upgrade (DAQ100 and TPX) greatly improved the readout speed by a factor of 10 and reduced the space taken by the current electronics. The iTPC will double the channel numbers of the required electronics in inner sectors. The pad-row readout is optimized for performance and cost with the design of pad size of 0.5x1.6 cm to be in-between the original inner sector pad size and the outer sector pad size. The group, which successfully deployed the DAQ1000 project, will be responsible for the new electronics that will use a new chip (SAMPA) being developed for ALICE. The University of Texas at Austin will be responsible for the 24 strongback production.

With the data that will be collected with RHIC BES-II, this group will also join the search for the phase boundary and possible critical point by looking at the fluctuations in event-by-event multiplicity distribution of conserved quantities like net-charge, net-baryon number and net- strangeness.

Time Table:

| | |
|---|---|
| 2016.1-2016.12 | Develop quality control procedure. Start mass production for all 24+6 iTPC MWPC chambers. |
| 2017.1-2017.12 | Ship to BNL, test and installation of iTPC at STAR. Commissioning. |
| 2018.1-2018.12 | Take data. Improve Calibration, Physics analysis |
| 2019.1-2019.12 | Take data. Physics analysis. |
| 2020.1-2020.12 | Physics analysis and publication of BES-II results. |

## IV. Sources of Funding and Its Use

A will apply for 3.8 million Yuan RMB from NSFC, in more detail:

| | |
|---|---|
| Small Equipment | 410K Yuan |

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| | |
|---|---|
| Graduate Students | 450K Yuan |
| Workshops | 450K Yuan |
| Consumables | 900K Yuan |
| Energy | 50K Yuan |
| Administration | 190K Yuan |
| Travel | 1150K Yuan (including international cooperation fee) |

The use of funding obeys NSFC's regulations and requirements.

B will apply for 2.35 million US dollars form DoE, in more detail:

| | |
|---|---|
| Small Equipment | 1370K USD |
| Labor | 200K USD |
| Workshops | 100K USD |
| Consumables | 200K USD |
| Energy | 60K USD |
| Administration | 100K USD |
| Travel | 120K USD |
| Exchange and collaboration | 200K USD |

## V. Ownership, Use and Transfer of the Intellectual Property

Intellectual property rights of the project cover all results obtained within the project. The IPR of common results will be shared by all parties concerned. The IPR of results obtained independently by one party without any assistance from the other party or obtained before or after the collaboration will belong to the respective party.

Authorship and acknowledgement in papers should be based on contribution to the project and decided in discussions involving all parties concerned.

Before submitting any application for related intellectual property rights, one party should first consult with the other party and may proceed only after the other party has agreed without objection on the ownership of the IPR.

Without the written consent of both parties, none of the project's common IPR

may be transferred to any third-party.

## VI. Duration, Amendment and Withdrawal

The project will terminate upon completion of all research activities, which is agreed on the date of March 5, 2015. A research partner who decides to withdraw from the project before the above-mentioned date should notice other members of the collaborative research at least three months before the change happens. Any amendments to this agreement should be agreed by both parties.

## VII. Legal Validity

This agreement comes into effect on Jan 1, 2016 and terminates on Dec 31, 2020. It is made in two counterpart originals and two counterpart copies, with one of the originals to be retained by each of the two parties and one of the copies to be retained by NSFC and Shandong University respectively.

## VIII.

Signature:

Party A: Qinghua Xu (PI)

Time: March 6, 2015

Place: SDU, China

Party B:

Flemming Videbaek (Co-PI, iTPC manager)

Zhangbu Xu (STAR Spokesperson)

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Time: March 6, 2015

Place: BNL, U.S.